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THESIS

IMPROVING THE QUALITY AND PERSONNEL FILL RATES OF U.S. ARMY RESERVE UNITS

by

John W. Brau, Jr.

June 2005

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A prior thesis created a database of 30,000 zip codes, 800 RCs, and 264 Military Occupational Specialties (MOSs) that included demographic, vocational, and economic data and past military recruit production. A second thesis established requirements and constraints on recruiting. Together with these two theses, this work will form the Unit Positioning and QUality Assessment Model (UPQUAM), an optimization model that considers unit manning and the Military Available Population (MAP). Results will indicate where the MAP best supports Army Reserve units. Each unit will be associated with an existing Reserve Center (RC) and those that are not supported within a Regional Readiness Command's (RRC) MAP will be highlighted for later consideration in another RRC.

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IMPROVING THE QUALITY AND PERSONNEL FILL RATES OF U.S. ARMY RESERVE UNITS

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ABSTRACT

The most critical component of sustaining combat-ready United States Army Reserve (USAR) units is manning. Traditionally, the USAR has focused on maintaining the Congressionally mandated End Strength Objective (ESO), a total force requirement, at the expense of manning individual units. Historically, the USAR has met the overall ESO, but some individual units have become unbalanced. Many have been successful at manning soldiers above their authorized strength while others have struggled. Massive mobilizations in support of the Global War on Terrorism (GWOT) have highlighted the importance of manning units to their proper "fill rates." The USAR has cross-leveled troops from overstrength to understrength units resulting in many problems. This thesis formulates and solves a model addressing the problem of maintaining appropriate AR unit manning.

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LIST OF ACRONYMS

ACRONYM	DEFINITION
AFQT	Armed Forces Qualification Test
AIT	Advanced Individual Training
ANOVA	Analysis of Variance
AR	Army Reserve
ARCOM	Army Reserve Command
ARNG	Army National Guard
ASG	Area Support Group
ASVAB	Armed Forces Vocational Aptitude Battery
BLS	Bureau of Labor and Statistics
BOLC	Basic Officer Leadership Course
BRAC	Base Realignment And Closure
BT or BCT	Basic Training or Basic Combat Training
CA	Combat Arms
CAR	Chief of the Army Reserve
CLG	Civil Life Gain
CS	Combat Support
CSS	Combat Service Support
CMA-R	Competitive Market Analysis – Reserve
CONUS	Continental United States
CONUSA	Continental United States Army
CPS	Current Population Survey
ESO	End Strength Objective
FEMA	Federal Emergency Management Area
FIP	Federal Information Partnership
FRRI	Federal Reserve Restructuring Initiative
FSA	Force Structure Allowance

ACRONYM	DEFINITION
FY	Fiscal Year
GP	General Population
HR-CMD	Human Resource Command
IET	Initial Entry Training
IRR	Individual Ready Reserve
LAU	Local Area Unemployment
LM	Linear Model
LP	Linear Programming
LSCAT	Line Score Category
MAP	Military Available Population
MEPS	Military Entrance and Examination Processing Station
MOS	Military Occupational Specialty
MOSQ	Military Occupational Specialty Qualified
MSO	Military Service Obligation
MSS	Market Supportability Study
MTOE	Modified Table of Organization and Equipment
MV50	Microvision 50 Lifestyle Segment Groupings
NLP	Non-Linear Program
NMA	National Market Analysis
NPS	Non-Prior Service
OCAR	Office of the Chief of the Army Reserve
OCAR-FP	Office of the Chief of the Army Reserve - Force Programs
OCAR-RTD	Office of the Chief of the Army Reserve -Retention Transition Division
OMAR	Operations and Maintenance Army Reserve
P-Factor	Personnel Factor
POM	President's Objective Memorandum
PS	Prior Service
RA	Regular Army

ACRONYM	DEFINITION
RC	Reserve Center
RDBMS	Relational DataBase Management System
REQUEST	Recruit Quota System
RRC	Regional Readiness Command
TDA	Table of Distribution and Allowance
TTHS	Training, Transient, Holdees and Students
TPU	Troop Program Unit
UA	Unit of Action
UE	Unit of Employment (may be X or Y)
UIC	Unit Identification Code
UPQUAM	Unit Positioning and QUality Assessment Model
USAR	United States Army Reserve
USARC	United States Army Reserve Command
USAREC	United States Army Recruiting Command
USBC	United States Bureau of the Census
USPS	United States Postal Service
USR	Unit Status Report
WOBC	Warrant Officer Basic Course
ZIP	Zone Improvement Plan

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EXECUTIVE SUMMARY

A critical component of sustaining combat-ready United States Army Reserve (USAR) units is manning. Traditionally, the USAR has focused on maintaining the Congressionally mandated End Strength Objective (ESO), a total force requirement, at the expense of manning individual units. Historically, the USAR has met the overall ESO, but some individual units became unbalanced. Many were very successful at manning soldiers above their authorized strength while others struggled. Massive mobilizations in support of the Global War on Terrorism (GWOT) have highlighted the importance of manning units to their proper "fill rates." The USAR cross-leveled troops from overstrength to understrength units resulting in many problems. This thesis formulates and solves a model addressing the problem of maintaining appropriate AR unit manning.

A prior thesis created a database of 30,000 zip codes, 800 Reserve Centers (RCs), and 264 Military Occupational Specialties (MOSs) that included demographic, vocational, and economic data and past military recruit production. A second thesis established requirements and constraints on recruiting. Together with these two theses, this work formed the Unit Positioning and QUality Assessment Model (UPQUAM), an optimization model that considers unit manning and the Military Available Population (MAP).

Our optimization model is a minimum-cost multi-commodity flow model with sole sourcing constraints, in which flows represent the filling of specific MOS requirements in specific units from the MAP as specified by MOS and zip code. We were able to solve the model successfully and position a pilot Regional Readiness Command (RRC's) subordinate units within its existing RCs while improving many measures of unit fitness. The model places more emphasis on higher-tier units and on filling Office Chief Army Reserve (OCAR's) priority MOSs. For our pilot RRC, it positions units within the recruiting market while increasing ready units, in terms of p-levels, by 70%. It also increased MOS fill-rates within the RRC by 100%. While the

model performed well, there needs to be some modifications of several features and a larger validation study before it should be used by the USAR.

I. INTRODUCTION

A. BACKGROUND

The US Army is composed of an active and reserve component. The active component is the Regular Army (RA) and the Reserve component consists of the United States Army Reserve (USAR) and the Army National Guard (ARNG). One of the most critical factors of making and sustaining combat-ready USAR Troop Program Units (TPUs) is manning. Historically, the USAR has focused on maintaining the Congressionally mandated End Strength Objective (ESO) giving less importance to the manning of individual units. Traditionally the USAR has met the overall ESO, but TPUs across the nation became unbalanced in terms of manning levels. Many units in parts of the country were very successful at manning soldiers above their authorized strength while others were unsuccessful and struggled to fully man their units. The massive mobilization of USAR TPUs in support of the Global War on Terrorism (GWOT) has highlighted the importance of manning units to their proper "fill rates." Because a great number of units were well below their manning requirements, the USAR relied upon cross-leveling troops from overstrength TPUs to deploying understrength TPUs. Inherent problems arose from cross-leveling that affect the overall combat readiness of the USAR. This thesis formulates and solves a model for maintaining TPU manning.

A prior thesis (Fair, 2004) laid the foundation for an optimization model that considers unit manning in light of the Military Available Population (MAP). His thesis was the first of three theses that, when combined, form the Unit Positioning and Quality Assessment Model (UPQUAM). He surmised that unit manning depends upon the location of Reserve Centers (RCs) with respect to the local demographics of the MAP. He built a database consisting of 30,000 zip codes, 829 RCs, and 264 Military Occupational Specialties (MOSs) "drawing on and integrating over a dozen disparate databases."[1] The database included demographic, vocational, and economic data along with a six-year historical average of military recruitment and MOS suitability for each of the 264 MOSs by zip code. Fair (2004) also provided an initial optimization network

[1] Martin Lynn Fair, "Geo-Demographic Analysis in Support of the US Army Reserve Unit Positioning and Quality Assessment Model (UPQUAM)," June 2004, page v.

model. A current thesis (Tatro, 2005) will provide the constraints limiting the unit manning decisions. The resulting optimization model and its solution is the focus of this study.

B. "BROKEN" USAR TROOP PROGRAM UNITS

Army Regulation 220-1 (Unit Status Report or USR) provides guidance on unit readiness. Four areas determine a unit's readiness rating. The personnel resource area is one of the four areas and the focus of this study. The regulation states:

> The personnel factor (p-level) is calculated by determining the assigned strength, then assessing the available strength, the available military occupational specialty qualified (MOSQ) strength, and the available senior grade strength against required MTOE/TDA unit strength. In the computation of personnel data, commanders are directed not to move soldiers from one unit to another, breaking up cohesive groups solely to cross-level for unit status reporting purposes.[2]

In mathematical terms, the unit fill rate is calculated as follows:

$$FILL_RATE_{MOS\&SKILL_LEVEL} = \frac{ON_HAND_{MOS\&SKILL_LEVEL}}{AUTHORIZED_{MOS\&SKILL_LEVEL}}$$

Equation 1.1: MOS Fill Rate Equation

Many USAR units have habitually been rated "not combat ready" and considered "broken" due to personnel issues. Each unit's Modified Table of Organization and Equipment (MTOE) or Table of Distributions and Allowances (TDA) lists its required number of soldiers. In many cases, enough soldiers are assigned to a TPU but individual soldiers are non-deployable for a variety of reasons. Soldiers are non-deployable if they are "trainees, transients, holdees or students." A trainee is any Army Reserve officer, warrant officer or non-prior service (NPS) enlisted soldier who has not completed the Basic Officer Leader Course (BOLC), Warrant Officer Basic Course (WOBC) or Initial Entry Training (IET) respectively. Transients are soldiers not available for duty because they are relocating between assignments. Holdees include soldiers who are not available for deployments due to medical, disciplinary, or pre-separation reasons. Lastly, soldiers

[2] Chapter 4 (Personnel Data), Subparagraph 4-1 (General), AR 220-1, 10 June 2003, page 22.

attending resident Professional Development Education (PDE) courses or MOS-producing courses that are 139 days or longer in duration are non-deployable. Table 1 below summarizes the p-level ratings.[3] A unit's overall p-level is determined by the lowest of the total available, MOSQ and Senior-Grade p-levels. Any p-level below level one places burdens on a unit's personnel to perform their wartime mission, and jeopardizes those soldiers.

Level for available, MOSQ, and Senior-grade strengths		
P LEVEL	Available	MOSQ/Senior-Grade
1	100-90%	100-85%
2	89-80%	84-75%
3	79-70%	74-65%
4	69% or less	64% or less

Table 1. AR 220-1, Table 4-1, Level for available, MOSQ, and Senior-Grade Strengths.

USAR soldiers in training, in a transient status, considered "holdees" or in a student status are non-deployable and lower a unit's p-level. Years ago, the RA created the Training, Transient, Holdees and Students (TTHS) account as a personnel management tool in recognition of the "overhead" in the personnel arena. The TTHS account allows the RA to remove non-deployable soldiers from its units and to fill these positions with deployable soldiers thus increasing unit readiness. Only recently has the USAR had a TTHS account available as a management tool. This will be discussed in subsequent paragraphs.

C. THE CHANGING ARMY

When the Soviet Union and the Eastern Block collapsed in 1989, the US capitalized upon the "Peace Dividend" and began a dramatic de-activation of Regular

[3] AR 220-1, Unit Status Report, 10 June 2003, Chapter 4-7, page 27.

Army Units. The Army reduced the number of active duty divisions from 18 to the current number of ten.[4] With the elimination of force structure, the Army no longer required many bases. Thus, the Army began a comprehensive study under the auspices of the Base Realignment And Closure (BRAC) Initiative. In the past two decades and with four rounds of BRACs, the Army has closed many bases that housed Regular Army Units. The Army is currently conducting a BRAC review that could result in the closing of another substantial number of installations. This could have a negative impact upon USAR units and should be included as part of future analysis.

Furthermore, the RA has started to transform from a "Cold War" footing of massive formations of tank and mechanized forces to one more capable of addressing the nation's current threats. The concept is to develop deployable units based on brigade-size elements that are capable of expeditionary and independent operations. The new modular structure is based upon a Unit of Action (UA) which includes Unit of Employments (UE) x and y organizations (UEx and UEy).[5]

In the past two decades, the Reserve components have also undergone dramatic reorganization. As recently as 1994, the Army decided, with the consent of Congress and the President, to realign the Reserve components' fundamental missions. The ANG's mission became primarily Combat Arms (CA) and Combat Support (CS) while the USAR's mission became Combat Service Support (CSS).[6] Like the active component, the Reserve component lost a great deal of force structure as part of the Cold War "Peace Dividend." The Army Reserve decreased from a Cold War high ESO of 319,000 to today's ESO of 205,600.

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[4] http://www4.army.mil/soldiers/archive/jun97/features/ng.html, 16 May 2005.

[5] UE is a temporary identity adopted to avoid sidetracking the Army's reorganization scheme with debates over what senior command echelons would be called. A UA is an integrated BDE-size combat team that is a permanent structure. This contrasts to the system being replaced in which BDE Task Forces were organized from disjoint units for specific missions. UEx's are tactical forces at either a divisional or corps level while UEy's are forces at the operational level such as echelons above corps or theater level. https://www.perscomonline.army.mil/EPada/ada_ltr.htm, AMD Soldier Transformation; The Way Ahead, Lt. Col. Dave Bagnati and Major (P) Randy McIntire. March 2005.

[6] Combat Arms consists of the following branches: Infantry, Armor, Field Artillery, Engineers, Air Defense Artillery and Aviation. Combat Support consists of the Chemical, Military Intelligence, Military Police and the Signal Branches. Combat Service Support consists of the Transportation, Ordinance, the Judge Adjutant General's, Finance, and Quartermaster Branches.

Furthermore, since the writing of Fair (2004), the current Commander Army Reserve (CAR), LTG James Hemley, has made sweeping changes to the structure of the USAR. He directed the reorganization of the USAR to accommodate the RA's UA transformation to UEx & UEy formations. Figure one lists the CAR's intent to restructure the force.

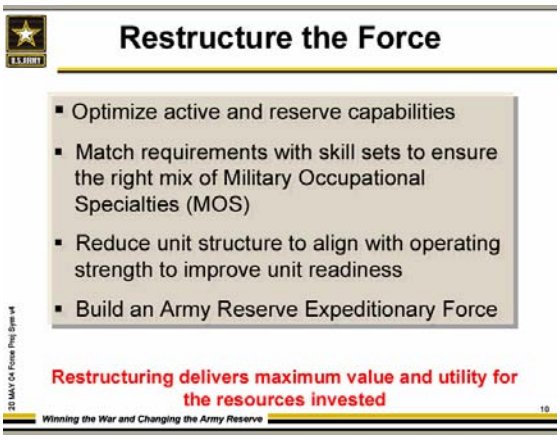


Figure 1. Slide from the CAR's 20 May 2004 briefing to Congress expressing his intent of USAR force restructuring.

He also addressed the long-standing personnel unit readiness issues mentioned in paragraph B above by implementing a "manpower inventory management system." Historically, the USAR has had on average 61,000 troops that were non-deployable due to TTHS reasons or because of misalignment. In the Federal Reserve Restructuring Initiative (FRRI), LTG Helmly directed the USAR to build a TTHS account by taking 20,500 required positions out of unit MTOE and TDA force structure. He also directed the USAR to align trained soldiers with unit positions that matched their skills. Although the ESO is still 205,300, the USAR TPU Force Structure Allowance (FSA) or operating strength is now 173,000.[7] Figure 2 depicts the Federal Reserve Restructuring Initiative.

[7] CAR's brief to the CSA. http://proceedings.ndia.org/4710/LTG_Helmly_20_May_04.pdf, March 2005.

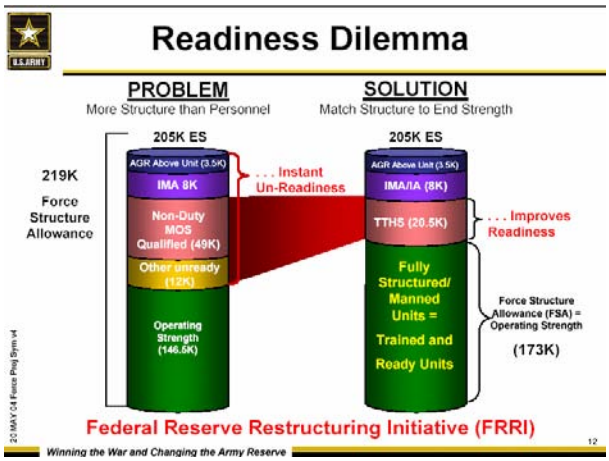


Figure 2. Slide from the CAR's 20 May 2004 briefing to Congress depicting the FRRI

The United States Army Reserve Command's Force Programs (USARC FP) Division is currently working to reorganize the entire USAR force structure to accommodate these changes. The USAR will deactivate many TPUs and close RCs. Units will be converted by retraining current soldiers and providing new equipment. Figures 3 and 4 summarize some of the pending changes in force structure. The number of combat-ready units will increase and be aligned with RA UAs creating synergy and unprecedented unit integrity and manpower levels. Ensuring that units are stationed in RCs within MAPs that support the accessing of soldiers is critical to unit fill and to transformation.

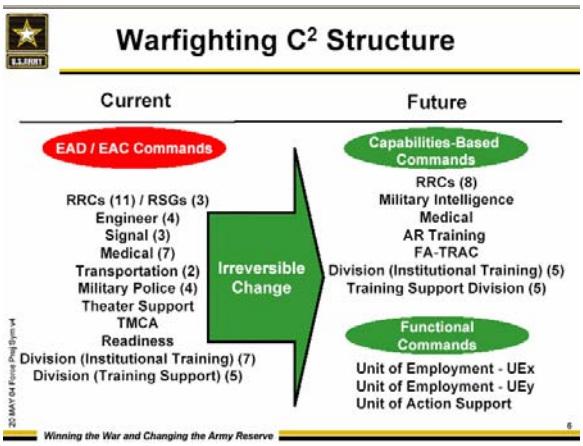


Figure 3. Slide from the CAR's 20 May 2004 briefing to Congress depicting C2 Structure Changes.

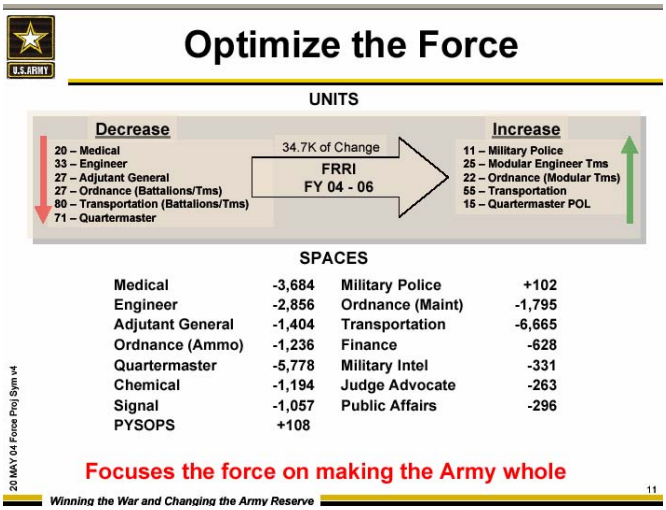


Figure 4. Slide from the CAR's 20 May 2004 briefing to Congress depicting C2 Structure Changes.

D. ACCESSING SOLDIERS INTO TROOP PROGRAM UNITS

Soldiers are accessed into TPUs by the US Army Recruiting Command (USAREC) and the Army Reserve Human Resource Command (HR CMD) at St. Louis. USAREC accesses non-prior service (NPS) soldiers and former soldiers who have completed their Military Service Obligations (MSO) from previous enlistments. The target age of NPS soldiers is 17 to 21. Former soldiers without a MSO are called Civil Life Gains (CLGs) and the target age is 22 to 29.5. The HR CMD is responsible for recruiting soldiers from the Individual Ready Reserve (IRR) to join TPUs.[8]

Regulations require USAR soldiers to live within 75 miles of their RC or within 90 minutes commute. The regulation is intended to increase the safety of soldiers by reducing commute times and to ease the financial burden of their travels. TPUs will not recruit or retain soldiers if a large part of their drill paycheck goes towards travel expenses.

[8] DOD Directive number 1235.13 dated November 19, 1997 defines the IRR as a manpower pool principally consisting of individuals who have had training and have previously served in the active forces or in the Selected Reserve. The IRR consists of obligors who must fulfill their Military Service Obligation (MSO) under 10 U.S.C. 651 (reference (a)), and those who have fulfilled their MSO and who voluntarily remain in the IRR. IRR members are subject to involuntary active duty (AD) or training and fulfillment of mobilization requirements, in accordance with (IAW) Sections 12301(a) and 12302 of reference (a). Additionally, the IRR also includes some personnel who are participating in officer training programs or in the Armed Forces Health Professions Financial Assistance Programs.

As stated previously, TPUs' authorized positions are listed in their MTOEs and TDAs. Job "vacancies" for the authorized positions are listed in the Recruit Quota System (REQUEST). USAREC has 6060 RA and 1000 USAR recruiters spread across the country missioned from REQUEST to recruit USAR and RA soldiers. For reserve recruiting, USAREC is responsible for locating and matching recruits with the appropriate Armed Services Vocational Aptitude Battery (ASVAB) scores that meet medical and moral requirements to vacancies within REQUEST.

In the mid 1990s when USAREC was struggling to achieve the USAR recruiting mission, Reserve leadership allowed units to double-slot and sometimes triple-slot soldiers in order to meet the ESO. For example, if a recruit wanted to enlist to be a truck mechanic and the local TPU had 20 soldiers with this specialty authorized and 20 soldiers on-hand, USAREC, in consultation with USARC, would override the personnel accounting system to allow this recruit to enlist. In this scenario, fill rates for this MOS in this TPU would increase beyond 100%, indicating overstrength. This policy led to many units becoming considerably overstrength in areas where the MAP had a higher propensity to enlist like the 2nd Recruiting Brigade in the South-Eastern part of the country. However, where recruiting suffered in other areas of the country because the MAP had a lower propensity to enlist, TPUs had low p-levels and hence were non-deployable.

E. CURRENT UNIT POSITIONING METHODOLOGY

The USAR's Unit positioning is executed by OCAR Force Programs (FPs). FPs receives from USAREC a Market Supportability Study (MSS). This study considers each unit's aggregate fill rate. Analysts study broken units and determine which units are not supportable by the MAP identified in the MSS. MSSs consider each TPU with a distinct Unit Identification Code (UIC) modeled against the projected increase in MAP, past production, unit losses, and other USAR and ANG units within the unit's distance and driving time constraint.[9] It is noteworthy to recognize here that USAREC's model input data is aggregated with no attention paid to the MAP's ASVAB test scores.

[9] Personal Interview with MAJ Robert Radtke, USAREC PAE, MSS Division, 3 February 2005.

USARC FPs analyzes the MSS in conjunction with other input factors such as FEMA Region requirements and political considerations to determine which RCs and units to deactivate, re-designate, relocate or activate.

F. DEFINING THE PROBLEM & GOAL OF THIS STUDY

Combat readiness of USAR TPU's has suffered for years due to shortfalls in trained soldiers.[10] The CAR reduced the Force Structure Allowance (FSA) by 20,500 soldiers to create a TTHS account in order to fix unit fill problems. Furthermore, the USAR is transforming unit structure to align with the RA's and ANG's changing force structure. These changes have precipitated the need to close RCs, deactivate many TPUs and to convert others to different types of units. With all of these changes, the USAR is at a critical point in time and can seize the opportunity to increase the combat readiness of the entire TPU force through careful analysis. Force programmers and other analysts involved with geographically positioning the USAR force structure can locate RCs and TPUs optimizing the MAP's ASVAB scores matched against unit manning requirements down to MOS level during this time of change. Although the current system functions, it has not done well as reflected in the current measurements of TPU personnel readiness. With the completion of this thesis, the third and final proposed by Fair (2004), the USAR will have a model available to redistribute broken TPUs to RCs based on ASVAB scores to better fill manning requirements.

G. RELATED RESEARCH

In addition to LTC Martin Fair's (2004) and MAJ Gary Tatro's (2005) theses that preceded this study, there has been a considerable amount of research and analysis concerning unit TPU positioning, USAR recruiting and TPU retention. USAREC's Program and Evaluation (PAE) Directorate has a research cell dedicated to studying the MAP and mapping it to TPUs in Market Supportability Studies (MSS). USAREC also develops and uses the Competitive Market Analysis – Reserve (CMA-R) which reports the local market availability of Army and sister service competition. USARC FPs has

[10] "A Quick Look at the Trainees, Transients, Holdees and Students Account," http://www4.army.mil/USAR/soldiers/tths.htm, January 2005.

conducted numerous internal studies and sought outside contractors to further assist in unit positioning. None of these studies, however, considers the MAP's ASVAB test scores nor each MOS's specific test score requirements as required by each individual TPU.

Previous recruiting and market studies determined that certain regions have MAPs that have a much higher propensity to enlist than other regions of the nation. USAREC's 2000 National Market Analysis (NMA) determined that TPU fill rates were highly correlated to their geographical location. Broken units tended to be in areas of the country where the MAP had lower propensity to enlist in the military. This critical fact will have a great impact on the outcome of the results of this study.

The Army Reserve's retention program has a large impact on a unit's fill. The USARC Retention Transition Division (USARC RTD)'s mission is to retain soldiers and to recover those Army Reservists who have stopped drilling. Recent analysis resulting from surveys of soldiers who left their TPUs to enter the IRR or to exit the service indicate that troops are upset with frequent and long deployments in support of the War on Terror.[11] There is much more work to be done in the area of retention and attrition. If the USAR can control TPU attrition, fill rates will become healthy over time. Retention and attrition are and will continue to be the focus of USAR research analysts.

[11] Will Congress Bring Back the Draft? http://www.fcnl.org/issues/item.php?item_id=1090&issue_id=37#, February 2005.

II. MODEL

A. PROBLEM DEFINITION

1. Scope of the Problem

This study is confined to the Military Available Population (MAP) that supports Non-Prior Service (NPS) skill level I enlisted recruitment, Troop Program Unit (TPU) position requirements and Military Occupational Specialty (MOS) fill rates. The model does not consider Non Commissioned Officer (NCO) positions. If this model increases skill level I fill rates to acceptable levels, junior enlisted soldiers should advance into the NCO ranks thus achieving acceptable fill rates at these higher enlisted grades. Also, the model does not address officer and warrant officer fill rates nor does it consider the Individual Ready Reserve (IRR) market. These latter two facets could be the work of follow-on studies and included in the model developed within this study.

2. Desired Model Results

This model will provide decision makers a list of Reserve Centers (RCs) with associated TPUs that are supportable to a specified target personnel fill rate within the respective recruiting market. The model considers priority MOSs and the priority of the unit. Where TPUs are not supportable, the model will attempt to "relocate" them to existing RCs that have excess capacity in terms of recruiting market. The desired end-state is that each Unit Identification Code (UIC) is positioned in a RC that can support its manpower requirements. Units that are unsupportable will be highlighted for decision makers' actions.

3. Ready Units

Units that are rated p-1 with respect to AR 220-1 are at an acceptable personnel fill rate and considered "ready units." A p-1 level means the unit is at least 90% filled with MOS qualified soldiers and, for the purpose of this study, considered positioned in a RC with a sufficient recruiting market to support its requirements. The P-rating or TPU fill rate is calculated by summing the number of on-hand MOS qualified soldiers and dividing it by the aggregated number of authorized soldiers for each MOS.

The formula follows:

$$TPU_FILL_RATE_{UIC} = \frac{\sum_{MOS} ON_HAND_{MOS\&UIC}}{\sum_{MOS} AUTHORIZED_{MOS\&UIC}} \qquad \forall \quad UIC$$

Equation 2.1: TPU Fill Rate Equation

Problems arise when soldiers are MOS qualified and double-slotted or triple-slotted against a position while other positions in the same unit go unfilled. In fact, the CAR has recognized this problem and directed commanders to fix "personnel alignment problems" by retraining, reclassifying or cross-leveling soldiers from over-strength MOSs to under-strength MOSs within TPUs.[12] Since misaligned soldiers are primarily a personnel management challenge and not a recruiting market supportability issue, the model uses the aggregated numbers to simplify matters and to support the CAR's decision to have leaders align soldiers properly.

4. Priority Units and MOSs

The Army Reserve prioritizes TPUs through a "tier" system based on the criticality of their missions and propensity to deploy. The model takes into account TPU prioritization using a weighting system. In addition, OCAR provides USAREC with a "sweet sixteen" list of priority MOSs. These MOSs change periodically based on the needs of the Army. The model weights the sweet sixteen and will be discussed in the next chapter along with TPU prioritization.

B. DATA

As stated previously, Fair spent a tremendous amount of time developing the dataset for the two follow-on theses.[13] We summarize his work here. Fair built four flat-file databases and then merged them into a single flat file. He drew from the following data sources:

- US Postal Service Zip Code Master File
- Bureau of Labor and Statistics (BLS) Vocational Master File

12 Speech given by LTC James Helmly, Army Reserve ORSA Symposium, 14-15 September 2004.

13 Fair details in pages 24 to 35 his painstaking labor and arduous efforts in gathering, cleaning and assimilating the data.

- Fill Rates of USAR units by Zip Code or market
- Force Structure File
- Local Area Unemployment (LAU) Master Data File
- Federal Information Partnership (FIP) Code Master Data File
- MOS Quality (QUALS) Master Data File
- Sister Service (Reserve) Accession Data
- All Army Accessioning Data

Figure 5 depicts the flat file databases along with their associated number of records and data fields.

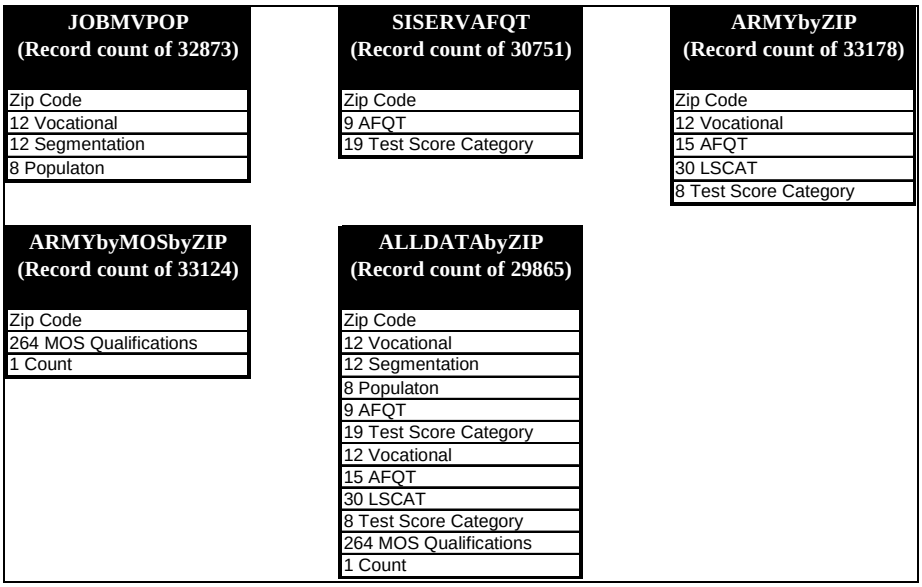


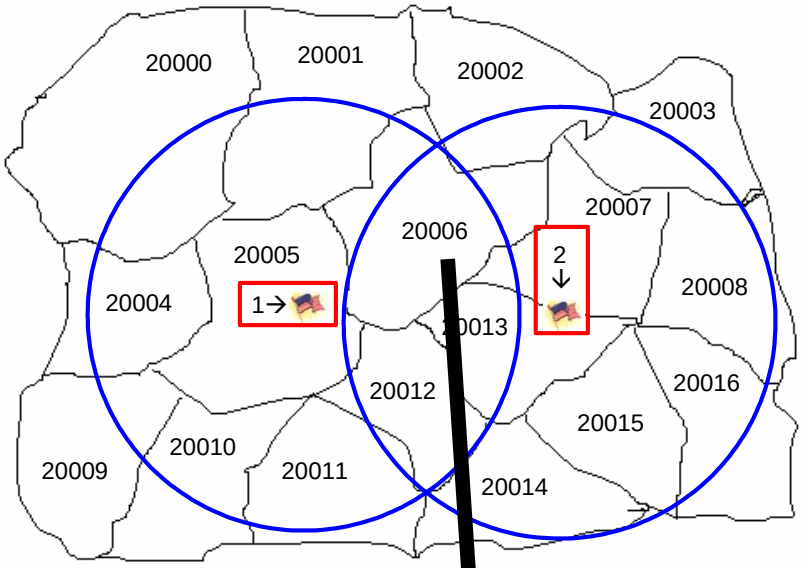
Figure 5. JOBMVPOP, SISERVAFQT, ARMYbyZIP and ARMYbyMOSbyZIP are intermediate flat files LTC Martin Fair built from a multitude of data sources. ALLDATAbyZIP is the merging of the four intermediate flat files into the final database used in this study.

Each database used zip codes as the primary key. The database titled JOBMVPOP contains 11 occupational and working class categories along with a totals column from the BLS, 11 Microvision 50 (MV50) Lifestyle Segment groupings, and eight miscellaneous fields. Each data entry represents the number of people for the specified zip code meeting recruiting age requirements as categorized by the 11 segment groupings. Both the BLS and MV50 data are snapshots in time. SISERVAFQT's 29 fields represent the six-year annual average of the contracts for each of the Reserve

services broken down by the ASVAB test score category. ASVAB test score categories include I, II, IIIA, IIIB and OTH. The file also includes aggregate columns for each service. ARMYbyZIP contains 66 fields. Fields include the six-year annual average recruiting production for each of the ASVAB test score categories for the RA, USAR and the ANG. ARMYbyMOSbyZIP contains fields for the 264 AR MOSs and an aggregate column for each zip code. Each data entry is a six-year annual average of the number of recruits that signed AR contracts that qualified for the specific MOS within the associated zip code. The aggregate column is the six-year annual average of the total USAR contracts for the specified zip code. The final file, ALLDATAbyZIP, merges the four previously mentioned files into a single file with 392 fields and 29,865 records.

C. THE MODEL CONCEPT

Our model is a minimum cost multi-commodity network flow model with sole-sourcing constraints. Each set of available recruits in each MOS, from each zip code is a commodity that will flow through a trans-shipment point (RC) to fill a UIC's authorizations. Figure 6 depicts two fictitious RCs and their associated market zip codes captured by the two circles representing a 75 mile radius. Table 1 of the figure includes RC 1's zip code, its market zip codes and two units stationed at the center represented by the Unit Identification Code (UIC). Each UIC has lists of the number of soldiers authorized, required, assigned and fill rates by MOS. One can see that UIC WVKJB0 has an overall fill rate of 117% while WQ68AA at 66% fill is broken. To further illustrate, zip code 20006 is shared by RCs 1 and 2. Analysis will provide the estimated total expected recruits from each zip code (table 2) and the total expected recruits qualified for an MOS by zip code (table 3). Zip code 20006 is expected to provide a total of 9 recruits to the MOSs associated with the UICs assigned to RC 1 or 2. The solution to the model is to optimally assign the UICs to RCs to maximize unit fill rates. If units do not meet the threshold value of a "healthy unit" (i.e., 90%), the model will attempt to re-locate it to an existing RC. With the reduction of force structure due to the creation of the TTHS account and the Army transformation, the AR is looking to close RCs in a cost saving effort. Hence, the model will allow for RCs to close; the UICs must, however, continue to exist.



Reserve Center	Reserve Center Zip	Market Zips	UICs	MOS	AUTH	REQ	ASSIGN	Fill
		20000	WVKJB0	25M1	1	1	1	100%
		20001		31U1	2	2	3	150%
		20003		54B1	1	1	1	100%
		20004		63B1	1	1	2	200%
		20005		71L1	3	3	1	33%
		20006		71M1	1	1	1	100%
		20007		74C1	2	2	3	150%
		20009		75B1	1	1	1	100%
		20010		88M1	4	4	5	125%
		20011		88N1	4	4	5	125%
		20012		92G1	1	1	1	100%
		20013		92Y1	2	2	3	150%
		20014		Total	23	23	27	117%
			WQ68AA	31F1	2	2	0	0%
				31U1	2	2	1	50%
				52C1	4	4	1	25%
				54B1	1	1	1	100%
				57E1	7	7	2	29%
				63B1	3	3	1	33%
				63J1	1	1	0	0%
				71G1	5	5	2	40%
				71L1	5	5	3	60%
				71M1	1	1	0	0%
				76J1	8	8	4	50%
				77F1	2	2	1	50%
				91A1	1	1	1	100%
				91B1	26	26	26	100%
				91D1	2	2	3	150%
				91E1	1	1	1	100%
				Total	71	71	47	66%

Table 1: RC 1's market zip codes, UICs, MOS manning numbers, and fill rates.

Zip	Total Expected
20000	12
20005	6
20006	9
20007	4
20009	7

Table 2: Predicted number of recruits (fictitious)

Zip	25M1	31U1	54B1	63B1	71L1
20000	4	4	9	6	12
20005	1	2	5	3	6
20006	**2**	**2**	**7**	**4**	**9**
20007	0	1	3	2	4
20009	2	2	6	3	7

Table 3: Predicted number (fictitious) of recruits qualified for shown MOS for the respective zip code

Figure 6. Fictitious example of two reserve centers and their associated recruiting market zip codes.

Before the model runs, we lock each healthy unit into its original RC by fixing the variable associating it with the RC. The model will initialize by locking-in healthy units to their respective RCs via a binary number, causing available recruits to flow into those units. Next, the model will flow recruits into broken units based on unit priority and the "sweet sixteen" priority MOSs, attempting to leave units in place. If units cannot be fixed in place, the model will attempt to place units into RCs that can support manning requirements.

D. BASIC MODELING APPROACH

There are four basic indices considered in this model. Since the data are broken down by zip code, reserve center, unit and MOS, these were the natural indices for all of the data and decision variables in a mathematical programming model. Our decisions are to determine the optimal positioning of units within existing RCs based on the MAP in to fill each MOS in each TPU. Because of geographic and operational restrictions, we break each of these decisions into individual flows that trace people with certain ASVAB scores qualifying for specific MOSs for specific units. These individuals flow characterized by their ASVAB scores from their associated zip codes through a RC into a unit and finally into a USAR MOS requirement. This will become clearer after examining the network flow schematic below.

E. SCALING THE PROBLEM

Studying the schematic, it quickly became apparent that when the model started searching for a solution the variables would grow tremendously if the entire USAR force structure was used in a single computational run. There are over 3.5 million binary variables (829 RCs times 4,268 UICs) controlling whether a UIC is stationed at a reserve center via $ASSOC_{r,u}$. Hence, we elected to scale the problem down by running the model iteratively by each Regional Readiness Command (RRC). This made practical sense because if a unit had to change RCs but could be kept within the RRC's area, moving costs and political fall-out would be minimized. Running the model at the RRC level dramatically reduced computational requirements. Another step reducing computational requirements and that made common sense was "locking-in" healthy UICs to their current RCs. This required determining each UICs' current fill rate and hard-wiring the applicable $ASSOC_{r',u}$ variable with a 1.

F. THE NETWORK FLOW SCHEMATIC

The network flow schematic for the simple example above follows.

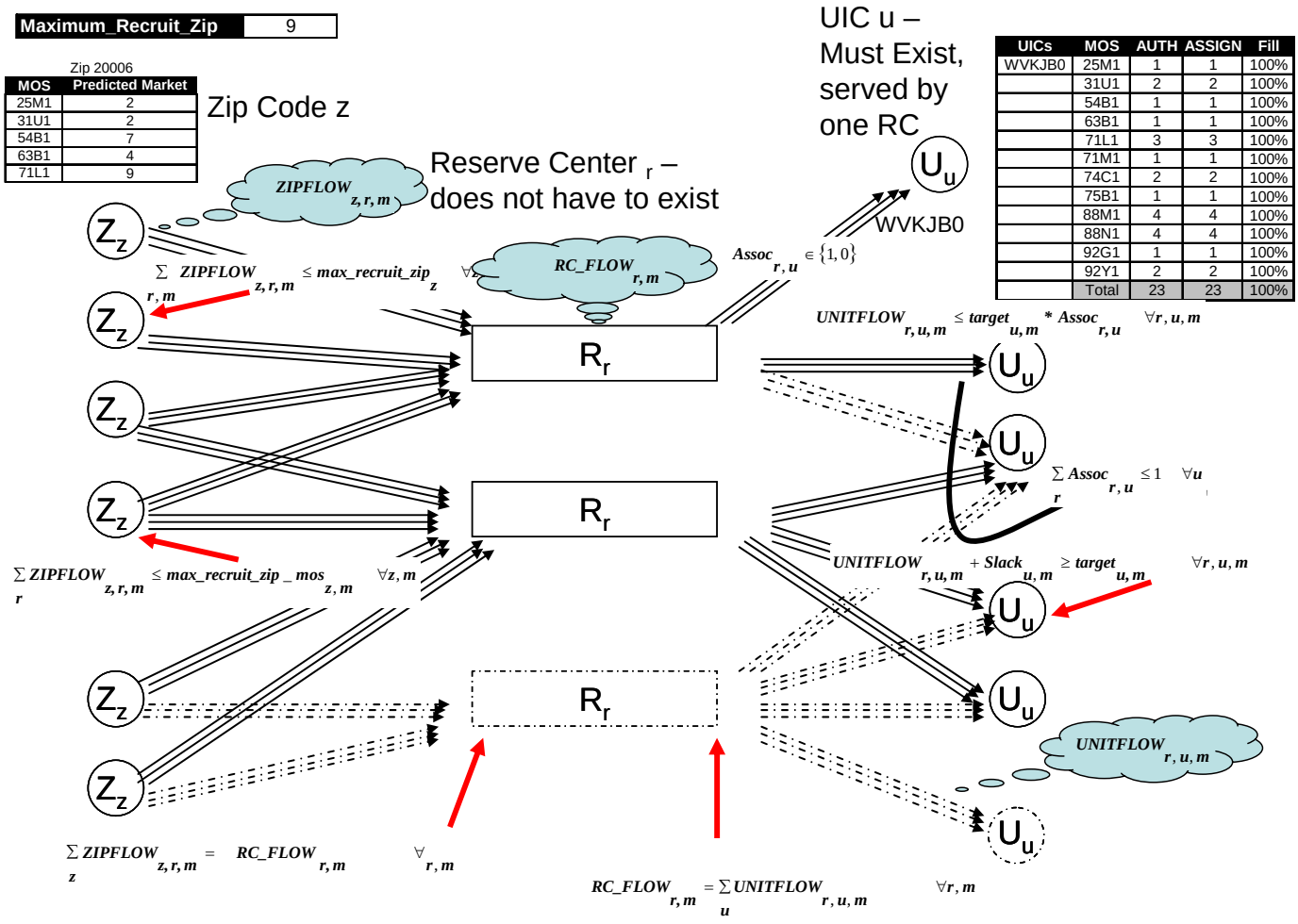


Figure 7. Network flow schematic

It will help clarify the basic modeling approach explained above and provide a reference for studying the model equations. Following the flow from left to right, recruits identified via prediction analysis from Tatro's (2005) thesis are treated as distinct commodities. Tatro's (2005) prediction analysis also provided a maximum supply of recruits for each zip code. Recruits distinguished by their MOS flow from their associated zip codes through RCs. Hence, RCs act as trans-shipment points. A zip code may provide recruits to multiple RCs. Flow continues from RCs to assigned UICs. A UIC must be stationed at only one RC, hence the count of flows into a UIC must not be

greater than one (1). To do this, the model associates a binary variable for each arc emanating from the RCs to associated UICs. The schematic portrays a possible model solution. Dashed lines and objects represent elements the model considered but failed to use. Here, the model elected to close a RC. All arcs emanating to and from the RC are eliminated. Solid circles representing UICs met fill rate goals while the one dashed circle did not. The model will attempt to locate the unsupportable UIC within the existing RC structure.

G. THE MODEL

The mathematical representation of the model follows along with a description of the objective function and the constraints:

Army Reserve Recruiting Realignment (ARRR)

INDICES:

z	ZIP codes of interest (00010…99985) [1,…,30,000]
r	Reserve Centers (The current number of RCs) [1,…,829]
u	Units (indexed by Unit Identification Codes, or UICs) [W05LAA,…WZXRAA,1-4268]
m	MOSs of interest (00B…98Z) [1,…,264]

PARAMETERS:

$max_recruit_zip_z$	Maximum number of recruits available in ZIP z
$max_recruit_zip_MOS_{z,m}$	Maximum number of recruits available in ZIP z of MOS m
$target_{u,m}$	Target number of recruits for MOS m in Unit u
$weight_m$	Weighting (priority) of MOS m assigned by OCAR [Sweet Sixteen]
$tier_u$	Weighting of UIC u based on its tier rating

NONNEGATIVE VARIABLES (*Note: All variables are non-negative)***:**

$ZIPFLOW_{z,r,m}$	Flow from ZIP Code z to RC r of MOS m
$RC_FLOW_{r,m}$	Flow through RC r of MOS m
$UNITFLOW_{r,u,m}$	Flow from RC r through UIC u to MOS m
$SLACK_{u,m}$	Shortfall of soldiers in MOS m in UIC u

BINARY VARIABLES:

$ASSOC_{r,u}$ $\begin{cases} 1 & \text{If there is flow from RC } \boldsymbol{r} \text{ to UIC } \boldsymbol{u} \\ 0 & \text{o/w i.e. UIC } \boldsymbol{u} \text{ is not located at RC } \boldsymbol{r} \end{cases}$

FORMULATION:

$$\min \sum_{u,m} \boldsymbol{weight_m} * \boldsymbol{tier_u} * \boldsymbol{SLACK_{u,m}} \tag{0}$$

$$\text{s.t.} \quad \sum_{r,m} \boldsymbol{ZIPFLOW_{z,r,m}} \le \boldsymbol{max_recruit_zip_z} \qquad \forall \boldsymbol{z} \tag{1}$$

$$\sum_{r} \boldsymbol{ZIPFLOW_{z,r,m}} \le \boldsymbol{max_recruit_zip_MOS_{z,m}} \qquad \forall \boldsymbol{z}, \boldsymbol{m} \tag{2}$$

$$\sum_{z} ZIPFLOW_{z,r,m} = RC_FLOW_{r,m} \qquad \forall r, m \qquad (3)$$

$$RC_FLOW_{r,m} = \sum_{u} UNITFLOW_{r,u,m} \qquad \forall r, m \qquad (4)$$

$$\sum_{r} ASSOC_{r,u} \leq 1 \qquad \forall u \qquad (5)$$

$$\sum_{r} UNITFLOW_{r,u,m} + SLACK_{u,m} \geq target_{u,m} \qquad \forall u, m \qquad (6)$$

$$UNITFLOW_{r,u,m} \leq target_{u,m} * ASSOC_{r,u} \qquad \forall r, u, m \qquad (7)$$

The objective function increases unit fill to a specified target captured in parameter $target_{m,u}$ for as many units as possible by associating (i.e. stationing) TPUs to RC's based on recruiting market supportability while identifying RCs for closure. Closing RCs could result in cost benefits for the USAR. Furthermore, the objective function prioritizes MOS fill based on the CAR's "Sweet Sixteen" priority MOSs and a unit's tier rating.

Constraint (1) limits the number of recruits per Zip Code to its maximum level determined via regression analysis

Constraint (2) limits the number of recruits in a given MOS per Zip Code to its maximum level determined via regression analysis

Constraint (3) is a balance-of-flow constraint that ensures the total flow from zip code *z* of MOS *m* to RC *r* is equal to the flow out of RC *r* for MOS *m*

Constraint (4) is a balance of flow constraint that ensures the flow from RC *r* of MOS *m* is equal to the total flow of MOS *m* from RC *r* to UIC *u*.

Constraint (5) is a sole-source constraint that ensures a UIC is located at only one RC.

Constraint (6) allows the model to find a feasible solution by using a slack variable. $SLACK_{u,m}$ identifies the shortfall of MOS *m* in UIC *u*.

Constraint (7) regulates the flow from RC *r* of MOS *m* into UIC *u* based on the binary variable $ASSOC_{r,u}$.

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III. DISCUSSION AND FINDINGS

A. DISCUSSION

1. Pilot RRC and Desired Output

As stated previously, the intent of the model is to provide decision makers a list of RCs with associated TPUs that are supportable to a specified target personnel fill rate within the respective recruiting market. Where TPUs are not supportable, the model attempts to "relocate" them to existing RCs that have excess capacity in terms of recruiting market. The desired end-state is that each UIC is positioned in a RC that can support its manpower requirements and that unsupportable units are highlighted for decision makers' actions. If the model identifies RCs for closure, this could assist the USAR in closing centers as a cost saving. To develop the optimal solution, we ran the model many times adjusting the objective function and parameters for the 70th RRC. We chose the 70th RRC as the pilot because it is relatively small. The table below lists measured criteria along with three columns of data. The "Baseline" column shows the criteria of the 70th RRC when the data was pulled. The next column shows the criteria after running the model where the target included a 20% attrition factor along with shortfalls of each MOS for each UIC. Furthermore, the objective function included weights for the "sweet sixteen" MOSs. The formula is Min $\sum_{u,m} \boldsymbol{weight_m} * \boldsymbol{SLACK_{u,m}}$. The third column shows the criteria after running the model with the same parameters as the second column except the objective function includes weights for unit tier ratings and the "sweet sixteen". The formula is Min $\sum_{u,m} \boldsymbol{weight_m tier_u} * \boldsymbol{SLACK_{u,m}}$

Criteria	Baseline	Objective Function includes MOS Weighting Only. TGT includes ASGN plus Expected Attrition	Objective Function includes Tier & MOS Weighting. TGT includes ASGN plus Expected Attrition
# of Healthy Units	27	44	47
# of Healthy MOSs	29	54	58
# of Broken MOSs	56	31	27
# UICs Moved	NA	37	36
Units Not Filled by Tier	6 x 1A 5 x 2A 28 x 2D 2 x 4A	2 x 1A 2 x 2A 18 x 2D 2 x 4A	19 x 2D 2 x 4D
Reserve Centers Not Used	NA	6Q24 6R02	6D08 6R02 6P05 6Q51
Sweet Sixteen Not Filled	63B1,38A1,37F191M1,92A1, 88M1,62E1,54B177W1,62H1	None	None
Recruits Utilized (Flow)	NA	633	633

Table 2. 70th RRC Comparison Table

The model improved the 70th RRC's baseline scores for the two runs. It performed exactly as designed filling the 68 units based upon the applicable weights within the objective functions. Where the objective function weighted only the "sweet sixteen" MOSs, all achieved 100% fill. However, four high priority units (1A and 2A) failed to achieve the targeted fill-rate. To address this problem, the next model run included weights for "sweet sixteen" MOSs and units' tier ratings. The results are in column three. This model improved the 70th RRC's scoring criteria even more; 47 out of 68 units and 58 out of 85 MOSs achieved the targeted fill rates. All "sweet sixteen" MOSs achieved fill rates and priority units were filled first. Lastly, this model also identified four RCs for closure as compared to the single-weight objective function that only identified two RCs. Without further study, we do not know if closing RCs is beneficial but there is potential cost savings for the USAR via infrastructure reduction.

2. Computing Requirement

GAMS easily ran the RRCs separately using the CPlex solver. See Appendix A for the specific code. Feasible solutions took less than a few minutes of run-time. A lot of data preparation prevented the solver from having to do needless computations. This consisted primarily of culling the data down to the RRC level. Furthermore, the model used filters to decrease the number of arcs and nodes considered.

3. "If It Ain't Broke, Don't Fix It"

Early runs "relocated" most of the TPUs from their incumbent RCs, even units that had healthy p-levels. This occurred because in scaling the data down to the RRC

level, we used MOS targets based on personnel shortfalls for UICs while ignoring healthy MOSs. Hence, the model moved a UIC that only needed a few soldiers to fill an MOS requirement to a new RC. It became apparent that the model needed to "fix" or associate healthy units to their current RCs to avoid this problem. We easily did this by calculating healthy units and their respective annual recruit requirements based on expected attrition figures. We "hard-wired" the applicable binary variables $ASSOC_{r,u}$ and set the respective recruiting (flow) parameters ($targets_{u,m}$) to the estimated annual attrition figures. This made sense because healthy units ought to remain in place and the model should "reserve flow" to sustain these units. This concept segued into the vision that the model would work perfectly and the USAR would reach a steady state p-level if all units were stationed at RCs that could provide the annual recruit production to replace soldiers that attrite. The two-weighted objective function model determined that the 70th RRCs recruiting market could accommodate 20% attrition for all units.

B. INPUT DATA

1. Requirement of Referential Integrity

In addition to the data files Fair (2004) provided for constraints one and two regression analyses, he also provided three files with unit, MOS and recruiting data. We used this data to develop the model parameters. In order to use this data, we combined the three files using S-Plus, Excel and Access. Access, however, was the most important tool in preparing the data. It was critical to build tables in Access that allowed for referential integrity. This was very meticulous and time consuming work, but once completed, ensured the data would execute properly within GAMS.

2. "Sweet Sixteen"

As stated in Chapter II, the "sweet sixteen" is a list of MOSs OCAR provides USAREC. Weighting the list and including it within the objective function worked well in filling the priority MOSs. The table follows:

MOS	Weight
63B1	1
88M1	0.99
95B1	0.98
92A1	0.97
54B1	0.96
77F1	0.95
38A1	0.94
51B1	0.93
62E1	0.92
77W1	0.91
77L1	0.9
37F1	0.89
55B1	0.88
62H1	0.87
31L1	0.86
91M1	0.85
All Other	0.75

Table 3. "Sweet Sixteen" plus weight

Running the model at the RRC level and including the "sweet sixteen" MOS weightings in the objective function provides an opportunity for the USAR to "regionalize" enlistment bonuses. This will be discussed further in the next chapter.

3. Priority Unit

The Army Reserve prioritizes TPUs through a "tier" system based on the criticality of their missions and propensity to deploy. The model takes into account TPU prioritization using a weighting system. Tiers with their associated weights follow:

Tier	Weight
1A	1
1B	0.9
1C	0.8
2A	0.7
2B	0.6
2C	0.5
2D	0.4
3	0.3
4A	0.2
5B	0.1

Table 4. TPU Tier rating with associated model weights.

C. LIMITATIONS / CONCERNS OF THE OPTIMIZATION MODEL

1. Decrementing Flow from Constraint Two

Fair (2004) built the regressors that Tatro (2005) used in regression analysis to provide the second constraint. Each figure in the constraint set represents the estimated number of recruits that qualifies for the associated MOS in a given zip code based on historical production. Hence, a recruit that scores extremely well on the ASVAB is counted in many MOSs across a single zip code. As this highly qualified recruit flows from a zip code to an MOS, the model decrements the associated MOS. It does not, however, decrement the other MOSs the soldier qualified for within the zip code. This is a major flaw allowing the model to count the soldier many times within the flow. In order to fix this, the model should include code that would look-up all other MOSs the soldier qualified for and decrement them.

2. Shortcomings of the Scaling

The model ran at the RRC level. It is practical to run the model at RRC level because the model attempts to locate UICs within the RRC versus moving them far across the country. As one would expect, running the model at the RRC level has its shortcomings. Preparing the data is very time consuming. Furthermore, RRCs do not necessarily contain all USAR units within their geographical boundaries. There are training divisions that are located in a RRCs area but are not part of the RRCs organizational structure. The best possible fix would be to run the MTOE and TDA requirements for the entire USAR at one time on a super computer and penalize for units moving great distances to decrease moving expenses.

3. Reserve Centers' Capacities

The model does not consider the physical capacities of the RCs. Hence, it might determine a unit could achieve a target fill-rate in a different RC but there might not be enough offices, motor pools, arms rooms, etc. to accommodate moving a TPU. If the model determined that the recruiting market could sustain a TPU at a RC that was at physical capacity, decision makers might decide to expand the RC or locate one nearby.

However, if decision makers were willing to build new facilities, we could relax the constraint that limits RCs to existing facilities and use the model to find areas in which to build new RCs.

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IV. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSIONS

The trilogy of theses proposed by Fair (2004) culminating in the Unit Positioning and QUality Assessment Model (UPQUAM) successfully positioned 70th RRC subordinate units within existing RCs while increasing many score criteria. The model with the objective function encompassing weights for a unit's tier rating and the "sweet sixteen" priority MOSs performed the best. It positioned units within the recruiting market while increasing ready units in terms of p-levels by 70%. It also increased MOS fill-rates within the 70th RRC by 100%. While the model performed well, there are some areas that must be worked prior to the USAR using it in the future listed in the recommendations paragraph below.

B. RECOMMENDATIONS

The model presented in this thesis may be a viable and useful tool to position USAR units and better man the force. It could also provide a tool for the "regionalization" of USAR enlistment bonuses. Before it could be used, however, much follow-on work needs to be done. Fair (2004) made critical assumptions that need in-depth analysis before UPQUAM can be recommended for implementation as a force structure positioning model. Fair's (2004) assumption that civilians are inclined to enlist for USAR jobs that are comparable to their civilian jobs has not been studied or proven. For instance, Fair's (2004) assumption would have over-the-road civilian truck drivers enlisting in the USAR as 88Ms (truck driver) or the local mechanic working at Midas enlisting as a 63T (automotive mechanic). This might be opposite from the truth where recruits enlist in MOSs that are very different than their civilian jobs to get a break from their daily routines and to learn other skills. Hence, civilian mechanics and truck drivers might want to enlist as infantryman or as medics. Furthermore, Fair (2004) created the predictors used in the regression analysis by combining MV50 lifestyle segments into 12 groupings and the BLS vocational categories into 12 other groupings. He did these groupings via logic and "subject matter expertise." A follow-on study should determine

whether the groupings are statistically sound. Once Fair's assumptions are proven and we move toward using the model, all of the data will need to be updated.

Since our data was obtained, the USAR has changed. The May 2005 BRAC identified many RCs for closure. Furthermore, many USAR MOSs have been renamed, consolidated or eliminated. The creation of the TTHS account coupled with the FRRI resulted in changes to a substantial number of TPUs. As the Global War on Terrorism continues for a fourth year, the USAR is experiencing the worst unplanned attrition in its history. As of 23 May 2005, the USAR has experienced 52 consecutive weeks of losses to the ESO. The OCAR strength manager reported:

> This report marks the 52nd consecutive week that SELRES strength has declined (i.e., the AR SELRES has not seen an increase in weekly strength in over one year). The Army Reserve (AR) is now 8,527 Soldiers below its 2% Congressional waiver authority floor of 200,900. During this span, the AR has seen a net loss of 18,777 Soldiers and during this fiscal year the AR has seen 11,488 net SELRES losses. Additionally, there are 14,149 non-participants (DFAS Date 04/20/05) and 7,840 Soldiers in the training pipeline.[14]

The two-year decrease in NPS enlistments, especially the past 52 weeks, and increase in attrition resulting in the downward trending end strength could have a significant impact on the model. Analysis should provide new attrition figures for inclusion in the model along with new figures for constraints one and two. Fair (2004) used six years' worth of recruiting data (1998 through 2003) to build the predictors for constraints one and two. Analysts should use caution in determining how much weight recent annual recruit production and TPU attrition should receive in light of the past two years of data.

Once the concerns above have been addressed, the last action needed to complete the model is to add the code to GAMS for constraint two to decrease the count of available recruits qualifying for MOS *m* for each recruit that flows from zip code *z* through RC *r* into UIC *u*. This requires looking at the ASVAB scores for each recruit that flows out of a zip code and decrementing not only the count for that MOS but also all of the MOSs he or she qualifies for with respect to the associated zip code.

[14] Email from MAJ Thomas Liuzzo, Strength Manager, OCAR HRD, 23 May 2005.

C. FURTHER RESEARCH

Questions requiring more study suggested above are to determine the propensity of people to enlist for MOSs that are similar to their civilian jobs. Also, Fair's (2004) groupings of BLS vocational categories and MV50 lifestyle segments that are the foundations of the underlying assumptions need to be validated. Other follow-on research should include attrition analysis to generate new figures for the model and hopefully provide commanders and decision makers insight into the causes. Lastly, the USAR has considered "regionalizing" enlistment bonuses for many years. Currently, because OCAR places incentives on MOSs at national level based on an aggregate fill-rate, sometimes the bonuses do not have their intended affect. For instance, the overall fill-rate for 88M (truck driver) might be short nationally, but healthy for an RRC. In this case, an enlistment bonus for 88M will do little good for this RRC. Running the model at the RRC level could provide insight as to which MOSs to weight and provide the tool for OCAR to regionalize enlistment bonuses.

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APPENDIX GAMS CODE

```
$title Army Reserve Recruiting Realignment
*-----------------DEFAULTS-------------------------------;
$OFFUPPER OFFSYMLIST OFFSYMXREF
$INLINECOM { }
$onempty

 OPTIONS
   LIMROW   = 0
   LIMCOL   = 0
   SOLPRINT = off
   ITERLIM  = 500000
   RESLIM   = 100000
   DECIMALS = 2
   LP       = CPLEX
   RMIP     = CPLEX
   MIP      = CPLEX
 ;
$ONTEXT
        Original: 20050518
                Author : W. Matthew Carlyle
        Description:  See ARRRform.doc

$OFFTEXT
*-----------------INDICES--------------------------------;

 SETS
   z       zip codes /
$INCLUDE zips.dat
   /
   r       RCs or reserve centers /
$INCLUDE rcs.dat
   /
   u       units/
$INCLUDE units.dat
   /
   m       MOSs/
$INCLUDE mos.dat
   /
   ;

 alias (z,zp) ;
 alias (r,rp) ;
 alias (u,up) ;
 alias (m,mp) ;

*-----------------DATA-----------------------------------;

 PARAMETERS
   max_recruit_zip(z) /
$ONDELIM
$INCLUDE reczips.csv
$OFFDELIM
   /
```

```
   max_recruit_zip_MOS(z,m)/
$ONDELIM
$INCLUDE reczipsmos.csv
$OFFDELIM
   /
   target(u,m)/
$ONDELIM
$INCLUDE target.csv
$OFFDELIM
   /
   tier(u)/
$INCLUDE tier.dat
/
   weight(m)/
$INCLUDE weights.dat
   /
 ;

 LOOP(m,
   IF(weight(m)=0.00,
     weight(m)=0.75;
   )
 );

 SCALAR
   value
 ;

*-----------------VARIABLES--------------------------------;

 VARIABLE
   OBJVAL          objective function value
 ;
 POSITIVE VARIABLES
   ZIPFLOW(z,r,m)  flow of MOS m from zip z to RC r
   RC_FLOW(r,m)    flow of MOS m through RC r
   UNITFLOW(r,u,m) flow of MOS m from RC r to unit u
   SLACK(u,m)      unmet demand of MOS m in unit u
 ;
 BINARY VARIABLES
   Y(r)         RC r is open or not
   ASSOC(r,u)   unit u draws from RC r
 ;

*-----------------EQUATIONS--------------------------------;

 EQUATIONS
   OBJ
   TOTAL_RECRUITS(z)
   MOS_RECRUITS(z,m)
   ZIP_RC_BAL(r,m)
   RC_U_BAL(r,m)
   SOLE_SOURCE(u)
   DEMAND(u,m)
   FLOW_LIMIT(r,u,m)
 ;
```

```
 OBJ..
   OBJVAL   =E= SUM((u,m)$(target(u,m)>0),weight(m)*tier(u)*SLACK(u,m))
 ;

 TOTAL_RECRUITS(z)..
   SUM((r,m)$(max_recruit_zip_MOS(z,m)>0), ZIPFLOW(z,r,m)) =L=
max_recruit_zip(z)
 ;

 MOS_RECRUITS(z,m)$(max_recruit_zip_MOS(z,m)>0)..
   SUM(r, ZIPFLOW(z,r,m)) =L= max_recruit_zip_MOS(z,m)
 ;

 ZIP_RC_BAL(r,m)..
   SUM(z,ZIPFLOW(z,r,m)$(max_recruit_zip_MOS(z,m)>0)) =E= RC_FLOW(r,m)
 ;

 RC_U_BAL(r,m)..
   RC_FLOW(r,m) =E= SUM(u$(target(u,m)>0), UNITFLOW(r,u,m))
 ;

 SOLE_SOURCE(u)..
   SUM(r, ASSOC(r,u)) =E= 1
 ;

 DEMAND(u,m)$(target(u,m)>0)..
   SUM(r,UNITFLOW(r,u,m)) + SLACK(u,m) =G= target(u,m)
 ;
 FLOW_LIMIT(r,u,m)$(target(u,m)>0)..
   UNITFLOW(r,u,m) =L= target(u,m)*ASSOC(r,u)
 ;

$INCLUDE fixedUIC.dat
 ;


 MODEL ARRR /
   OBJ
   TOTAL_RECRUITS
   MOS_RECRUITS
   ZIP_RC_BAL
   RC_U_BAL
   SOLE_SOURCE
   DEMAND
   FLOW_LIMIT
 / ;

 SOLVE ARRR USING MIP MINIMIZING OBJVAL ;

*-----------------Ugly Report-------------------------------;

 FILE outfile /70thTierAddedOnHandAttritTgtUgly.out/;
 put outfile;

 put 'ARRR Report' /;
 LOOP(u,
   LOOP(r$(ASSOC.l(r,u)>0),
```

```
     put 'Unit ',u.tl,' associated with RC ',r.tl /;
   );
   value=0.0;
   LOOP(m$(target(u,m)>0),
     put '  MOS ',m.tl,' target ',target(u,m):4:0,' slack
',SLACK.l(u,m):4:0 /;
     value=value+weight(m)*SLACK.l(u,m);
   );
   put ' Weighted slack penalty: ',value:8:4 /;
 );

 putclose outfile;

*------------------Scorecard Report-------------------------------;

 FILE scorefile /70thTierAddedOnHandAttritTgtScoreCard.out/;
 put scorefile;
 LOOP(u,
   LOOP(m$(target(u,m)>0),
     put u.tl,',',m.tl,',',target(u,m):4:0,',',SLACK.l(u,m):4:0 /;
   );
 );
 putclose scorefile;

*------------------Associate Report-------------------------------;
 FILE ASSOCfile /70thTierAddedOnHandAttritTgtASSOCIATE.out/;
 put ASSOCfile;

 put 'UIC Associated with RC Report' /;
 LOOP(u,
   LOOP(r$(ASSOC.l(r,u)>0),
     put 'Unit ',u.tl,' associated with RC ',r.tl /;
   );
   value=0.0;
    );

 putclose ASSOCfile;
```

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   Ft. Belvoir, Virginia

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   Atlanta, Georgia

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